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## Medical Implications of High Altitude Combat

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This article was previously published in  
*U.S. Army Medical Department Journal*  
April-June 2003

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Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>APR 2003</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2003 to 00-00-2003</b>	
4. TITLE AND SUBTITLE <b>Medical Implications of High Altitude Combat</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Foreign Military Studies Office,101 Meade Avenue,Fort Leavenworth,KS,66027</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>8</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# Medical Implications of High Altitude Combat

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## Introduction

The fact that a piece of land is inaccessible, uninhabitable, or of little practical value is no guarantee that nations will not fight over it. Long, bloody wars have been fought and are being fought for inhospitable mountain real estate located between 10,000 and 23,000 feet (3050 and 7015 meters) in elevation. Examples of such high altitude combat include the 1953 to 1974 Chinese invasion of Tibet and subsequent guerrilla war, the 1953 to 1958 Mau-Mau rebellion where British troops fought rebels in the Aberdares mountains of Kenya, the 1962 Sino-Indian War in the Himalayan mountains bordering Bhutan and Tibet, Soviet-Mujahideen combat in Afghanistan's Hindu Kush mountains from 1979 to 1989, the Peruvian government's clashes with *Sendero Luminoso* guerrillas in the Andes throughout the 1980s, and the Indo-Pakistan continuing conflict over the ownership of the Siachen glacier which began in April 1984. Recent (1999) Indo-Pakistani clashes in the Kargil area of disputed Kashmir again demonstrate that high altitude combat is often contemporary combat. Tens of thousands of combatants have perished in inhospitable ice, snow, and rock while battling for national prestige, water rights, survival, or geographic positioning. The U.S. Army has not had to fight at such altitudes, but with the war on terror, the possibility of U.S. military commitment to such areas is not all that remote. Operation Anaconda, in Afghanistan, is the highest altitude ground fight (10,500 feet) in U.S. history. Since the U.S. Army is still inexperienced fighting at these altitudes, it should draw from the experience of others. There are some distinct medical problems that medical personnel should plan for in the event of a high altitude contingency operation.

## High Altitude Medical Considerations

The world's highest mountains are in the Himalayan and Karakoram mountain chains of Asia. The Himalayan Mount Everest towers at 29,028 feet (8,853.5 meters) whereas the highest point in the United States, Mount McKinley in Alaska, is 20,320 feet (6,197.6 meters). The

highest point in the Colorado Rockies is Mount Elbert at 14,433 feet (4,402.1 meters). The highest point in the European Alps is Mont Blanc at 15,771 feet (4,810.2 meters).<sup>1</sup> Man is not naturally adapted to live and work at these high altitudes. Any time a person travels to an altitude of 8,000-10,000 feet (2440-3050 meters) or higher, the atmospheric changes in pressure and available oxygen cause physiological changes which attempt to ensure that the body gets enough oxygen.<sup>2</sup> These physiological changes are pronounced among mountain peoples, who have lived in the cold and higher altitudes for generations. Their bodies are short, squat, stocky and barrel-chested compared to those of lowlanders, and their hands and feet are stubby. Their hearts are bigger and their bodies contain 20% more red blood cells. Their red blood cells are larger than those of lowlanders. Their heart rate is slower and their capillaries are wider. The alveoli in their lungs are more adept at oxygen absorption. Many develop a fatty epithelial pouch around the eyes to counteract cataract and snow blindness.<sup>3</sup>

High altitudes are characterized by extreme cold, strong winds, "thin" air, intense solar and ultraviolet radiation, and rapidly changing weather including severe storms which can cut off contact for a week or longer. Personnel should be screened and acclimated before deploying to high altitudes since these conditions at high altitude are usually more dangerous than enemy fire. Medical personnel should prepare for the special demands of high altitude treatment and care. Bullet and fragment wounds, which normally are not serious, can quickly prove fatal at altitude. Movement in the high mountains often results in broken bones, severe lacerations and contusions, and internal injuries caused by falls and falling rock. Frostbite and hypothermia are a constant danger. Acute mountain sickness, high altitude pulmonary edema, and cerebral edema are frequently fatal consequences of working at high altitude. Mental and physical abilities decrease at high altitude and it also induces personality disorders. Sudden weight loss is often a problem. The rarefied atmosphere permits increased ultraviolet ray exposure which causes problems with sunburn and snow

blindness. High altitude shelter heating is often by unvented kerosene stoves, which means that personnel breathe air that is thick with soot. Medical personnel will be exposed to the same dangers of working in high altitudes and much of their normal medical equipment will not function, or function effectively, at high altitudes. For example, hospital generators and vehicles are often diesel-powered. Diesel engines lose efficiency at 10,000 feet (3050 meters) and eventually do not work at all due to the thinness of oxygen at higher elevations. Helicopters cannot haul heavy loads over 13,000 feet (3965 meters) as their rotors lack air dense enough to provide lift. Altitude requires additional animal or gasoline-fueled overland transport which adds to the physical demands and logistic requirements of medical support in this environment.

### Screening and Acclimatization

At high altitude, there is less oxygen and atmospheric pressure. The soldiers selected for high altitude duty should be screened for their ability to function in this environment. Soldiers should be in excellent physical condition and have sound cardiopulmonary systems. Short, wiry soldiers are preferable to tall, over-muscled soldiers. Selected soldiers should possess a higher level of intelligence in order to allow them to readily adapt to the hostile environment.<sup>4</sup> Personnel who have had radial keratotomy corrective eye surgery should not go "to altitude" as their vision may permanently cloud. Personnel records should be screened for previous high altitude sickness. Some personnel can be administered acetazolamide (Diamox) prophylaxis, however, personnel with sulfa allergy or G6PD deficiency cannot use acetazolamide. Personnel with the sickle cell trait should be excluded since rapid exposure and dehydration could set them up for splenic syndrome. Further, certain medications (any benzodiazepine such as Valium) inhibit acclimatization and personnel using these should be carefully evaluated.<sup>5</sup>

All personnel should undergo an acclimatization program to accustom them to their new environment and to improve their cardiopulmonary systems. A physically fit soldier can adapt to the cold in about 3 weeks.<sup>6</sup> Experience further shows that the body normally adapts to a new altitude in about 2 weeks. During the acclimatization phase, the body accumulates additional red blood cells which help transport oxygen.<sup>7</sup> The Pakistani Army

acclimates their personnel over a 7-week cycle. They begin with a 3-week stay at 10,000 feet (3050 meters), where personnel acclimate to the cold while they undergo daily physical conditioning and learn mountaineering, rock climbing, rope rappelling, and mountain survival. During the final 4 weeks, the soldiers learn advanced mountaineering techniques, trek to 14,000 feet (4270 meters), return and trek to 17,000 feet (5185 meters) and then return and finally trek to 19,135 feet (5836 meters).<sup>8</sup> Despite all training and efforts, acclimatization is not possible at altitudes over 18,000 feet (5418 meters), so personnel exposure at these altitudes must be limited and closely supervised.<sup>9</sup>

Medical personnel should advise logisticians and planners on special considerations for high altitude combat. For example, lightweight, pre-cooked, high-caloric, high-carbohydrate rations are essential and aid acclimatization. Supplementary candy and soups will help offset the inevitable loss of appetite at high altitude. Boiling snow for water requires fuel, so provisions have to be made to provide water or water purification equipment to the soldiers "at altitude" where dehydration is a constant threat. Noncommissioned officers need to "push water" to compensate for the diuresis of acclimatization. Troops working above 15,000 feet should be issued pressurized sleeping bags. These bags, which are inflated with a foot pump, have been tested to provide equivalent pressure of 8,370 feet (2550 meters) while at 13,600 feet (4150 meters).<sup>10</sup> Medical personnel should further recommend a rotation program where highest altitude exposure is limited to 10 to 14 day periods.

During the Soviet-Afghan War, Soviet physicians and physicians' assistants often accompanied small units on high altitude missions, since the patients required immediate medical care and evacuation took too long to save many patients.<sup>11</sup> Limited medical staffing in the U.S. Army will prevent many physicians and physician's assistants from accompanying the high altitude patrols. Therefore, the brunt of the responsibility for saving injured and sick soldiers will fall on the combat medic. In addition to the medic's normal skills, he will need to be trained in mountain rescue techniques, treatment of altitude-specific medical problems, and high altitude evacuation procedures. The medic should accompany the unit during acclimatization and rotate in and out of the high altitude area with the unit.



In an emergency, Diamox can be given to nonacclimated personnel (125 mg twice a day) starting the day before ascent and up to 2 days after ascent. However, this is an emergency measure that should only be used for a forced ascent to over 10,000 feet in 1 day. Normal acclimatization is preferable. There are side effects to Diamox, such as peripheral paresthesias and bone marrow suppression. The possibility of bone marrow suppression is relatively rare, but cannot be ignored.<sup>12</sup>

### **Frostbite**

Frostbite is the most common injury at altitude. Frostbite is a continual danger, but especially following any exertion. Sweat rapidly freezes around the toes and fingers. Frostbite may be classified as frostnip, superficial frostbite, or deep frostbite, depending on the severity of the case. Frostnip usually occurs on the tips of the ears, nose, fingers, toes, and cheeks and is noticeable as a whitening of the skin. Simple warming of the area is usually sufficient treatment. If it advances to superficial frostbite, the affected areas will be firm and have a white waxy appearance. Warming and gentle massaging of the area are the necessary treatment. As the area rewarms, it may turn a mottled blue or purple and swell. Nerve damage may also accompany superficial frostbite. In case of deep frostbite, major areas of tissue are frozen and killed. The areas are cold, pale, solid, and hard. Infection and amputation often result. The patient must be evacuated. Medics should be cautioned that once the frozen area is thawed, do not allow it to refreeze and do not thaw unless continual warmth and litter evacuation are available. It may be necessary to prevent thawing in order for the injured soldier to walk out. Once thawing occurs, the severe pain prevents the patient from walking out, although codeine, aspirin, or morphine should help the patient.<sup>13</sup> Evacuation at altitude is often difficult. Weather or weight limitations may prevent helicopters from flying to the patient. Often, patients must be carried on stretchers to lower elevations where the helicopters can operate. Soviet experience fighting in the mountains of Afghanistan proved that 13 to 15 men might be involved in carrying out one patient. Exertion at altitude is difficult and the stretcher party had to provide its own security as well.<sup>14</sup>

### **Hypothermia**

Hypothermia is the result of the body losing heat

faster than it can be produced. The body's core temperature begins to decrease and the patient shivers violently, has trouble using his hands, and is generally clumsy. When the core temperature falls to 90°F - 95°F (32°C - 35°C), the patient becomes uncoordinated, has difficult speaking, and is disoriented and apathetic. As the core temperature continues to decrease, the patient becomes more irrational, lapses into semiconsciousness, and eventually unconsciousness with subsequent cardiac arrest. If the patient cannot be rewarmed on site, the patient needs to be evacuated. Medics should be equipped with the mountaineering hydraulic sarong - a rewarming device that wraps around the patient and circulates a warmed liquid around the patient's body using a camp stove or catalytic generator. "Hot oxygen" breathing units, which use a soda lime and CO<sub>2</sub> reaction to warm oxygen, can also aid in rewarming the body core.<sup>15</sup> When a hypothermia casualty's body core temperature drops below 90°, when he stops shivering, or when he passes out, extra care must be given to handling him or he may develop cardiac arrhythmia and sudden death.<sup>16</sup>

### **Falls and Climbing Injuries**

Fractures, severe lacerations and contusions, or internal injuries often result from falls or falling rock injuries. The basic principles of trauma care should be followed. Medics should examine the patient for spinal injury as one of the first checks. Medics should not hesitate to put cervical collars on fall victims with suspected cervical spine injuries, particularly since these can usually be cleared in the field, avoiding unnecessary and hazardous evacuation.<sup>17</sup> Field splinting and immobilization should also be done before the patient is moved. The spleen, liver, and kidneys are the most likely organs to rupture and bleed internally from a fall. A torn diaphragm or intestine is also a possibility in falls and climbing injuries.<sup>18</sup>

### **Mountain Sickness, High Altitude Pulmonary Edema, and Cerebral Edema**

Mountain sickness or altitude sickness normally begins as a headache that may be associated with insomnia, loss of appetite, vomiting, cough, shortness of breath, irregular breathing, tightness in the chest, loss of coordination, swelling around the eyes and face, general weakness, and reduction in urine output. The patient

will lose physical coordination and mental acuity and tire quickly after mild activity. Mountain sickness normally takes at least 24 hours to develop, but nonacclimated personnel often develop the symptoms within 6 to 12 hours if they are quickly transported to elevations at 11,475-14,750 feet (3500-4500 meters). Treatment involves awareness of potential problems, rest, sleep, and adequate nutrition. Should that fail, the patient should descend to a lower altitude for a few days rest until improvement.<sup>19</sup>

Moderate mountain sickness involves the same symptoms, but their intensity increases and urine output is often less. If a day of rest does not help the patient, he or she should be immediately transported to a lower altitude. Usually, an early descent means an early recovery.<sup>20</sup>

Severe mountain sickness occurs in about 2% -3% of mountain sickness cases and involves high altitude pulmonary edema or cerebral edema. Twenty percent of acute, severe mountain sickness cases are fatal. Signs and symptoms of high altitude pulmonary edema, the accumulation of fluid in the lungs, include persistent cough, gurgling chest sounds, red frothy sputum, breathlessness, and tachypnea and tachycardia. Younger soldiers (under age 25) and soldiers with a history of pneumonia or other respiratory illness are prone to high altitude pulmonary edema. The symptoms of cerebral edema include headache, difficulty in balance, loss of coordination, and labored breathing. Severe mountain sickness may prove fatal within a few hours. Proficient medics may administer nifedipine and dexamethsone and administer oxygen or use a Gammow bag (a pressurized bag).<sup>21</sup> The patient still needs to be transported to a lower altitude. Oxygen, Diamox, Tylenol, aspirin, codeine, Decadron, Valium, Lasix, Phenergan, or morphine have all been used to help the patient during descent.<sup>22</sup>

The best prevention of mountain sickness is a gradual ascent with plenty of fluids and food provided to the soldiers. Climbing soldiers need to avoid overexertion. The worst approach is to drive or fly the soldiers from low to high altitude and then require them to finish the ascent.<sup>23</sup>

### **"Siachen Syndrome"**

The change in barometric pressure and reduced

quantity of oxygen at high altitude leads to mental status changes as well as physiological and psychosomatic changes. The Pakistani Army has noted that for every rise in a thousand feet, a person's temperament may change. A good-natured soldier at 19,000 feet may become irrational and selfish at 20,000 feet, introverted at 21,000 feet and unhinged at 22,000.<sup>24</sup> Although not recognized as a disease, the so-called Siachen syndrome has been noted among veterans fighting on the Siachen glacier. Its symptoms include disorientation and various psychological disorders. The experience has resulted in psychiatric treatment for some of the veterans.<sup>25</sup> Team-building, discipline, and productive activity help prevent the apathy which leads to Siachen syndrome.<sup>26</sup>

### **Training the Medical Force for High Altitude**

The Soviet Union had a special course to train physicians to function effectively at high altitude. The course was founded in 1987 – in the seventh year of the Soviet-Afghan War. The course was taught at the Kirghizistan medical institute with the usual medical courses and it prepared military and civilian physicians for mountain rescue and high altitude treatment duties. The course met twice monthly in 90-minute sessions. The course devoted 34 lecture hours and 74 hours of practical application to medical topics. Another 792 hours were devoted to mountaineering training, of which 47 were lecture and the remainder practical application.<sup>27</sup> Although it would be difficult to find the time to train U.S. military physicians to the same standard, the medical topics taught at the course may prove of value when planning a training course for medical personnel who may serve at high altitudes (See table on following page).

Medics training for high altitude combat will necessarily involve many of the same skills needed in mountain search and rescue units. Medics will have to know how to rig patients and litters for evacuation from precarious positions. The search and rescue community has a wealth of information that can be tapped for military medical use. Search and rescue personnel in the Yosemite National Park region developed a field medical kit for use by emergency medical treatment and technician personnel. It can be carried in a single medium-sized pack with an internal frame or carried by several members of the unit since the kit is divided into modules. This kit provides a starting point for planning a high altitude medic's kit.<sup>29</sup>

Topic	Lecture (hours)	Practical exercise
Introduction to goals, missions, and content of high altitude medicine.	2	2
Special features of high altitude physiology. Acclimatization to high altitude: short- and long-term. Mountain pathology.		
Acute mountain sickness: etiology, pathogenesis, clinical picture, treatment, and prevention. Pulmonary edema.	2	2
Effects of high altitude on the nervous system, heart vessels, excretory system, gastrointestinal tract, and circulatory system. Diagnosis, treatment, and prevention.	2	2
Peculiarities of the course of "normal" illnesses at high altitude.	2	2
Directing an acclimatization program. Personnel selection and prognosis of their health in the mountains. Medical oversight and preventive medical examinations.	2	2
Examination.	-	2
Special features of mountain trauma. First aid for accidents.	-	2
Diagnosis of trauma, broken bones of the extremities, methods of moving immobile patients.	2	4
Evacuating patients in the mountains.	-	4
Wounds, methods of stopping hemorrhage, bandaging.	2	6
Depression.	4	4
Traumatic shock, first aid for shock from mountain accidents, and trauma.	2	4
Emergency medical service and transport of patients with trauma to the head, spine, chest, stomach, and pelvis.	2	6
Special features of medical treatment for freezing, frostbite, and snow blindness.	2	-
Emergency medical service for drowning victims.	2	-
Examination.	-	2
Special aspects of organizing medical support for forces in the mountains.	2	-
Rigging medical gear for evacuation and treatment in the mountains.	2	2
Screening soldiers for service in the mountains.	2	4
Oxygen equipment and its use.	2	4
Training drills for high altitude treatment.	-	20
TOTAL	34	74

*Combined Physician's Curriculum for Mountain Rescue and Combat<sup>28</sup>*

## Thinking Lofty Thoughts

The U.S. military is faced with a variety of challenges as it converts from a forward-deployed to an expeditionary force. Part of being an expeditionary force is planning and preparing for contingency missions in various regions. One possible contingency is deployment to a high altitude region. The U.S. Army active

component and Army National Guard units that currently train in the mountains and Alaska are already aware of some of the problems involved in working at altitude and in the cold. They know that such a contingency mission would be difficult, but with proper foresight and preparation, medical personnel can meet the challenge and protect the force.



<p><b>Diagnostic Module</b></p> <p>Scissors  Blood pressure cuff  Stethoscope  Watch with sweep second hand  Penlight  Hemostat  Two thermometers (clinical and hypothermia)  Two pair tweezers  Three airways (adult, child, and pedi)  One syringe bulb  One 50 mL suction syringe and catheter</p>	<p><b>Intravenous Module</b></p> <p>Two 1000 mL bags lactated Ringer's  One 500 mL bag 5% dextrose in water  Two Macro solution sets  One Pedi solution set  Two 20-gauge catheter needles  Two 18-gauge catheter needles  Two 16-gauge catheter needles  Two 14-gauge catheter needles  Two 19-gauge butterfly needles  Two 21-gauge butterfly needles  One roll 13 mm tape  Five gauze pads, 5x5 mm  10 Band Aids  10 alcohol swabs  Four towelettes  Three tourniquets</p>
<p><b>Trauma and Dressing Module</b></p> <p>Two triangular bandages  Two Kerlix  Four Kling  Six Surgipads, 20x19 cm  Three rolls of tape  One Ace bandage  One Betadine scrub  Three swabs  Six towelettes  10 gauze pads, 10x10 mm  10 Band Aids  Two Steri-strips, 13x100 mm  Two Steri-strips, 6x75 mm  One pair bandage scissors  10 ammonia inhalants  One 25x75 cm large trauma dressing</p>	<p><b>Drug Module</b></p> <p><b>Injectable:</b> Two Meperidine HCL (Demerol) 100 mg  One Benadryl 50 mg  One Xylocaine (Lidocaine) 100 mg  Two Narlozone (Narcan) 0.4 mg  Two Epinephrine (adrenalin) 1:1000 1 mg  One Valium 10 mg  One 25 g Dextrose in 50 mL preloaded syringe  Two bicarbonate preload  Topical Neosporin ointment  Syringes &amp; needles  Three 3 mL with needles  Two 1 mL with needles  Five alcohol swabs</p> <p><b>Oral:</b> 15 aspirin tablets  10 Second tablets, 100 mg  10 Dexadrine tablets, 5 mg  10 Codeine tablets  20 Salt tablets  20 Lomotil tablets  Syrup of Ipecac  Activated charcoal</p>
<p><b>Splints Module</b></p> <p>Two full-leg air splints  One arm air splint  One ankle air splint  One wrist air splint  One wire ladder splint  One cervical collar  One towel for cervical collar  Trauma dressing</p> <p><b>Oxygen Module</b></p> <p>One D tank of oxygen  Oxygen mask and nasal cannula  Two oxygen bottles</p>	<p><b>Signal and Survival Module</b></p> <p>Flare gun and three flares  Orange hand-held smoke flare  Signal mirror  Whistle  Compass  Knife  Matches  Pencil and pad  Yellow plastic tube tent  Two space blankets  Maps  Toilet paper</p>



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